REDOX REACTION

6.0 Introduction :

Redox reactions shows vital role in non renewable energy sources. In cell reactions where oxidation and reduction both occurs simultaneously will have redox reaction for interconversion of energy.

6.1 Redox Reaction (Oxidation-Reduction) :

Many chemical reactions involve transfer of electrons from one chemical substance to another. These electron-transfer reactions are termed as **oxidation-reduction** or **redox reactions.**

Or

Those reactions which involve oxidation and reduction both simultaneously are known as oxidation reduction or redox reactions.

Or

Those reactions in which increase and decrease in oxidation number of same or different atoms occurs are known as redox reactions.

6.2 Oxidation State :

Oxidation state of an atom in a molecule or ion is the hypothetical or real charge present on an atom due to electronegativity difference.

Or

Oxidation state of an element in a compound represents the number of electrons lost or gained during its change from free state into that compound.

Some important points concerning oxidation number :

(1) Electronegativity values of no two elements are same –

$P > H$ $\quad$ $C > H$ $\quad$ $S > C$ $\quad$ $Cl > N$

(2) Oxidation number of an element may be positive or negative.

(3) Oxidation number can be zero, whole number or a fractional value.

Ex. $Ni(CO)_4 \Rightarrow$ O.S of Ni = 0

$N_3H \Rightarrow$ O.S of N = $-1/3$

$HCl \Rightarrow$ O.S of Cl = -1

(4) Oxidation state of same element can be different in same or different compounds.

Ex. $H_2S \Rightarrow$ O.S of S = -2

$H_2SO_3 \Rightarrow$ O.S of S = $+4$

$H_2SO_4 \Rightarrow$ O.S of S = $+6$

6.3 Some helping rules for calculating oxidation number :

(A) In case of covalent bond :

(i) For homoatomic molecule

$$\begin{array}{lccc} & A - A & A = A & A \equiv A \\ & \downarrow \quad \downarrow & \downarrow \quad \downarrow & \downarrow \quad \downarrow \\ \text{O.N. :} & 0 \quad 0 & 0 \quad 0 & 0 \quad 0 \end{array}$$

(ii) For heteroatomic molecule (EN of B > A)

$$\begin{array}{lccc} & A - B & A = B & A \equiv B \\ & \downarrow \quad \downarrow & \downarrow \quad \downarrow & \downarrow \quad \downarrow \\ \text{O.N. :} & +1 \quad -1 & +2 \quad -2 & +3 \quad -3 \end{array}$$

(iii) The oxidation state of an element in its free state is zero. Example- Oxidation state of Na, Cu, I, Cl, O etc. are zero.

(iv) Oxidation state of atoms present in homoatomic molecules is zero.

Ex. H_2 , O_2 , N_2 , P_4 , S_8 = zero

(v) Oxidation state of an element in any of its allotropic form is zero.

Ex. $C_{Diamond}$, $C_{Graphite}$, $S_{Monoclinic}$, $S_{Rhombic}$ = 0

(vi) Oxidation state of all the components of an alloy are 0.

Ex. $\underset{0\quad\ \ 0}{\overset{}{(\underset{\downarrow}{Na} - \underset{\downarrow}{Hg})}}$

(vii) In complex compounds, oxidation state of some neutral molecules (ligands) is zero.

Ex. CO, NO, NH_3, H_2O.

(viii) Oxidation state of fluorine in all its compounds is –1.

(ix) Oxidation state of IA & II A group elements are +1 and +2 respectively.

(x) Oxidation state of hydrogen in most of its compounds is +1 except in metal hydrides (-1)

Ex.	NaH	LiH	CaH_2	MgH_2
	↓ ↓	↓ ↓	↓ ↓	↓ ↓
O.S. :	+1 –1	+1 –1	+2 –1	+2 –1

(xi) Oxidation state of oxygen in most of its compounds is -2 except in -

(a) Peroxides $(O_2^{-2}) \rightarrow$ Oxidation state (O) = -1

Ex. H_2O_2 , BaO_2

(b) Super Oxides $(O_2^{-1}) \rightarrow$ Oxidation state (O) = -1/2

Ex. KO_2

↓

-1/2

(c) Ozonide $(O_3^{-1}) \rightarrow$ Oxidation state (O) = -1/3

Ex. KO_3

↓

-1/3

(d) OF_2 (Oxygen difluoride)

F – O – F

↓

Oxidation state (O) = + 2

(e) O_2F_2 (dioxygen difluoride)

↓

Oxidation state (O) = + 1

(xii) Oxidation state of monoatomic ions is equal to the charge present on the ion.

Ex. $Mg^{+2} \rightarrow$ Oxidation state = +2

(xiii) The algebric sum of oxidation state of all the atoms present in a polyatomic neutral molecule is 0.

Ex. $H_2\underline{S}O_4$

If O.S of S is x then

$2(+1) + x + 4(-2) = 0$

$x - 6 = 0$

$x = +6$

Ex. $H_2\underline{S}O_3$

If O.S of S is x then

$2(+1) + x + 3(-2) = 0$

$x - 4 = 0$

$x = +4$

(xiv) The algebric sum of oxidation state of all the atoms in a polyatomic ion is equal to the charge present on the ion.

Ex. $\underline{S}O_4^{-2}$

If O.S of S is x then

$x + 4(-2) = -2$

$x - 6 = 0$

$x = +6$

Ex. $H\underline{C}O_3^-$

If O.S of C is x then

$+1 + x + 3(-2) = -1$

$x - 4 = 0$

$x = +4$

(B) In case of co-ordinate bond (EN of B > A) :

$$\begin{array}{lcccccccccccc} & A & \rightarrow & A & \quad & B & \rightarrow & B & \quad & A & \rightarrow & B & \quad & B & \rightarrow & A \\ & \downarrow & & \downarrow & & \downarrow & & \downarrow & & \downarrow & & \downarrow & & \downarrow & & \downarrow \\ \text{O.S.:} & +2 & & -2 & & +2 & & -2 & & +2 & & -2 & & O & & O \end{array}$$

(C) In case of Ionic bond :

Charge on cation = O.S of cation

Charge on anion = O.S of anion

Ex.

$$\begin{array}{lccc} NaCl \rightarrow & Na^+ & + & Cl^- \\ & \downarrow & & \downarrow \\ & +1 & & -1 \\ MgCl_2 \rightarrow & Mg^{+2} & + & 2Cl^- \\ & \downarrow & & \downarrow \\ & +2 & & -1 \end{array}$$

Illustrations

Illustration 1. Oxidation number of cobalt in $[Co(NH_3)_6]Cl_2Br$ is –

(1) +6 (2) Zero (3) +3 (4) +2

Solution. Let the oxidation number of Co be x

Oxidation number of NH_3 is zero

Oxidation number of Cl is –1

Oxidation number of Br is –1

Hence, $x + 6(0) - (1 \times 2) - 1 = 0$

$\therefore \quad x = +3$

So, the oxidation number of cobalt in the given complex compound is +3.

Illustration 2. The order of increasing oxidation numbers of S in S_8, $S_2O_8^{-2}$, $S_2O_3^{-2}$, $S_4O_6^{-2}$ is given below –

(1) $S_8 < S_2O_8^{-2} < S_2O_3^{-2} < S_4O_6^{-2}$ (2) $S_2O_8^{-2} < S_2O_3^{-2} < S_4O_6^{-2} < S_8$

(3) $S_2O_8^{-2} < S_8 < S_4O_6^{-2} < S_2O_3^{-2}$ (4) $S_8 < S_2O_3^{-2} < S_4O_6^{-2} < S_2O_8^{-2}$

Solution. The oxidation number of S are shown below along with the compounds

S_8	$S_2O_8^{-2}$	$S_2O_3^{-2}$	$S_4O_6^{-2}$
0	+6	+2	+2.5

Hence the order of increasing oxidation state of S is –

$S_8 < S_2O_3^{-2} < S_4O_6^{-2} < S_2O_8^{-2}$

Illustration 3. The oxidation number of Cl in $NOClO_4$ is –

(1) +11 (2) +9 (3) +7 (4) +5

Solution. The compound may be written as $NO^+ \ ClO_4^-$.

For ClO_4^-, Let oxidation number of Cl = a

$$a + 4 \times (-2) = -1$$

$$a = +7$$

Hence, the oxidation number of Cl in $NOClO_4$ is + 7

Illustration 4. The two possible oxidation states of N atoms in NH_4NO_3 are respectively –

(1) +3, +5 (2) +3, –5 (3) –3, +5 (4) –3, –5

Solution. There are two N atoms in NH_4NO_3, but one N atom has negative oxidation states (attached to H) and the other has positive oxidation states (attached to O). Therefore evaluation should be made separately as –

Oxidation states of N is NH_4^+

$a + 4 \times (+1) = +1$

$\therefore \ a = -3$

Oxidation states of N in NO_3^-

and $a + 3(-2) = -1$

$\therefore \ a = +5$

Here the two oxidation states are –3 and +5 respectively.

Illustration 5. The oxidation states of S in $H_2S_2O_8$ is –

(1) +8 (2) –8 (3) +6 (4) +4

Solution. In $H_2S_2O_8$, two O atoms form peroxide linkage i.e.

```
          O          O
          ↑          ↑
H – O – S – O – O –S – O – H
          ↓          ↓
          O          O
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$$2 \times 1 + 2a + 6(-2) + 2(-1) = 0$$

$$\therefore \ a = +6$$

Thus the oxidation states of S in $H_2S_2O_8$ is +6

Illustration 6. The oxidation number of S in $(CH_3)_2$ SO is –

(1) 1 (2) 2 (3) 0 (4) 3

Solution. Let the oxidation number of S is 'a'

Oxidation number of $CH_3 = +1$

Oxidation number of $O = -2$

$2(+1) + a + (-2) = 0$

$$a = 0$$

Hence the oxidation no. of S in dimethyl sulphoxide is zero.

BEGINNER'S BOX-1

1. In which of the following compounds, the oxidation state of I-atom is highest ?

(1) KI_3 (2) KIO_4 (3) KIO_3 (4) IF_5

2. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is –

(1) +3 (2) +2 (3) +1 (4) –1

3. Oxidation number of Ni in $Ni(CO)_4$ is –

(1) 0 (2) 4 (3) 8 (4) 2

4. Positive oxidation state of an element indicates that it is –

(1) Elementry form (2) Oxidised (3) Reduced (4) Only reductant

5. Predict the highest and lowest oxidation state of (a) Ti and (b) Tl in combined state.

(1) a[0, +3] b[0, +2] (2) a[+3, 0] b[+4, 0] (3) a[+4, 0] b[+4, 0] (4) a[+4. +2] b[+3, +1]

6. The oxidation state of oxygen atom in potassium superoxide is –

(1) Zero (2) –1/2 (3) –1 (4) –2

6.4 APPLICATIONS OF OXIDATION NUMBER :

(A) To compare the strength of acid and base :

Strength of acid α Oxidation Number

Strength of base α $\dfrac{1}{\text{Oxidation Number}}$

Example : Order of acidic strength in HClO, $HClO_2$, $HClO_3$, $HClO_4$ will be.

Solution :

	Oxidation Number of chlorine
HClO (Hypo chlorous acid)	+1
$HClO_2$ (Chlorous acid)	+3
$HClO_3$ (Chloric acid)	+5
$HClO_4$ (Perchloric acid)	+7

$\because$ Strength of acid α Oxidation Number

So the order will be -

$HClO_4 > HClO_3 > HClO_2 > HClO$

(B) To determine the oxidising and reducing nature of the substances :

Oxidising agents are the substances which accept electrons in a chemical reaction i.e., electron acceptors are oxidising agent.

Reducing agents are the substances which donate electrons in a chemical reaction i.e., electron donors are reducing agent.

Highest O.S.	+4	+5	+5	+6	+7	+6	+7	+8	+8	+2	+1
Elements	C	N	P	S	Cl	Cr	Mn	Os	Ru	O	H
Lowest O.S.	-4	-3	-3	-2	-1	0	0	0	0	-2	-1

(a) If effective element in a compound is present in maximum oxidation state then the compound acts as oxidising agent.

Ex.	$KMnO_4$	$K_2Cr_2O_7$	H_2SO_4	SO_3	H_3PO_4	HNO_3	$HClO_4$
	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$
	+7	+6	+6	+6	+5	+5	+7

(b) If effective element in a compound is present in minimum oxidation state then the compound acts as reducing agent.

PH_3	NH_3	CH_4
$\downarrow$	$\downarrow$	$\downarrow$
–3	–3	–4

(c) If effective element in a compound is present in intermediate oxidation state then the compound can act as oxidising agent as well as reducing agent.

HNO_2	H_3PO_3	SO_2	H_2O_2
$\downarrow$	$\downarrow$	$\downarrow$	$\downarrow$
+3	+3	+4	–1

(C) To calculate the equivalent weight of compounds :

The equivalent weight of an oxidising agent or reducing agent is that weight which accepts or loses one mole electrons in a chemical reaction.

(a) Equivalent weight of oxidant = $\dfrac{\text{Molecular weight}}{\text{No. of electrons gained by one mole}}$

Example : In acidic medium

$$6e^- + Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O$$

Here atoms which undergoes reduction is Cr. Its O. S. is decreasing from +6 to +3

$$\text{Equivalent weight of } K_2Cr_2O_7 = \frac{\text{Molecular weight of } K_2Cr_2O_7}{3 \times 2} = \frac{M}{6}$$

Note :- [6 in denominator indicates that 6 electrons were gained by $Cr_2O_7^{2-}$ as it is clear from the given balanced equation**]**

(b) Equivalent weight of a reducant = $\dfrac{\text{Molecular weight}}{\text{No. of electrons lost by one mole}}$

In acidic medium, $C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$

Here, atoms which undergoes oxidation is C. Its oxidation state is increasing from +3 to +4.

Here, Total electrons lost in $C_2O_4^{-2}$ = 2 So, equivalent weight of $C_2O_4^{-2} = \dfrac{M}{2}$

(c) In different conditions a compound may have different equivalent weight because, it depends upon the number of electrons gained or lost by that compound in that reaction.

Example :

(i) $MnO_4^- \longrightarrow Mn^{+2}$ (acidic medium)
(+7) (+2)

Here 5 electrons are taken by MnO_4^- so its equivalent weight $= \dfrac{M}{5} = \dfrac{158}{5} = 31.6$

(ii) $MnO_4^- \longrightarrow MnO_2$ (neutral medium) or (Weak alkaline medium)
(+7) (+4)

Here, only 3 electrons are gained by MnO_4^- so its equivalent weight $= \dfrac{M}{3} = \dfrac{158}{3} = 52.7$

Note : When only alkaline medium is given consider it as weak alkaline medium.

(iii) $MnO_4^- \longrightarrow MnO_4^{-2}$ (strong alkaline medium)
(+7) (+6)

Here, only one electron is gained by MnO_4^- equivalent weight $= \dfrac{M}{1} = 158$

Note :- $KMnO_4$ acts as an oxidant in every medium although with different strength which follows the order –

acidic medium > neutral medium > alkaline medium

while, $K_2Cr_2O_7$ acts as an oxidant only in acidic medium as follows

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$

$(2 \times 6) \longrightarrow (2 \times 3)$

Here, 6 electrons are gained by $K_2Cr_2O_7$ equivalent weight $= \frac{M}{6} = \frac{294}{6} = 49$

(D) To determine the possible molecular formula of compound :

Since the sum of oxidation number of all the atoms present in a compound is zero, so the validity of the formula can be confirmed.

GOLDEN KEY POINTS

SOME OXIDIZING AGENTS/REDUCING AGENTS WITH EQUIVALENT WEIGHT :

Species	Changed to	Reaction	Electrons exchanged or change in O.N.	Eq. wt.
MnO_4^-(O.A.)	Mn^{+2} in acidic medium	$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	5	$E = \frac{M}{5}$
MnO_4^-(O.A.)	MnO_2 in neutral medium or in weak alkaline medium	$MnO_4^- + 3e^- + 2H_2O \longrightarrow MnO_2 + 4OH^-$	3	$E = \frac{M}{3}$
MnO_4^-(O.A.)	MnO_4^{2-} in strong alkaline medium	$MnO_4^- + e^- \longrightarrow MnO_4^{2-}$	1	$E = \frac{M}{1}$
$Cr_2O_7^{2-}$(O.A.)	Cr^{3+} in acidic medium	$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$	6	$E = \frac{M}{6}$
MnO_2(O.A.)	Mn^{2+} in acidic medium	$MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$	2	$E = \frac{M}{2}$
Cl_2(O.A.) in bleaching powder	Cl^-	$Cl_2 + 2e^- \longrightarrow 2Cl^-$	2	$E = \frac{M}{2}$
$CuSO_4$(O.A.) in iodometric titration	Cu^+	$Cu^{2+} + e^- \longrightarrow Cu^+$	1	$E = \frac{M}{1}$
$S_2O_3^{2-}$ (R.A.)	$S_4O_6^{2-}$	$2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$	2 (for two moles)	$E = \frac{2M}{2} = M$
H_2O_2(O.A.)	H_2O	$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$	2	$E = \frac{M}{2}$
H_2O_2(R.A.)	O_2	$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$ (O.N. of oxygen in H_2O_2 is –1 per atom)	2	$E = \frac{M}{2}$
Fe^{2+}(R.A.)	Fe^{3+}	$Fe^{2+} \longrightarrow Fe^{3+} + e^-$	1	$E = \frac{M}{1}$
I^- (R.A)	I_2 (in acidic medium)	$2I^- \longrightarrow I_2 + 2e^-$	2 (for two moles)	$E = \frac{M}{1}$
I^- (R.A)	IO_3^- (in basic medium)	$I^- + 6OH^- \longrightarrow IO_3^- + 3H_2O + 6e^-$	6	$E = \frac{M}{6}$

Illustrations

Illustration 7. Find the n-factor of reactant in the following chemical changes.

(i) $KMnO_4 \xrightarrow{H^+} Mn^{2+}$ (ii) $KMnO_4 \xrightarrow{H_2O} Mn^{4+}$

(iii) $KMnO_4 \xrightarrow{OH^-\text{(concentrated basic medium)}} Mn^{6+}$ (iv) $K_2Cr_2O_7 \xrightarrow{H^+} Cr^{3+}$

(v) $C_2O_4^{2-} \rightarrow CO_2$ (vi) $FeSO_4 \rightarrow Fe_2O_3$

(vii) $Fe_2O_3 \rightarrow FeSO_4$

Solution (i) In this reaction, $KMnO_4$ which is an oxidizing agent, itself gets reduced to Mn^{2+} under acidic conditions.

$$n = |1 \times (+7) - 1 \times (+2)| = 5$$

(ii) In this reaction, $KMnO_4$ gets reduced to Mn^{4+} under neutral or slightly (weakly) basic conditions.

$$n = |1 \times (+7) - 1 \times (+4)| = 3$$

(iii) In this reaction, $KMnO_4$ gets reduced to Mn^{6+} under basic conditions.

$$n = |1 \times (+7) - 1 \times (+6)| = 1$$

(iv) In this reaction, $K_2Cr_2O_7$ which acts as an oxidizing agent reduced to Cr^{3+} under acidic conditions. (It does not react under basic conditions.)

$$n = |2 \times (+6) - 2 \times (+3)| = 6$$

(v) In this reaction, $C_2O_4^{2-}$ (oxalate ion) gets oxidized to CO_2 when it is reacted with an oxidizing agent.

$$n = |2 \times (+3) - 2 \times (+4)| = 2$$

(vi) In this reaction, ferrous ions get oxidized to ferric ions.

$$n = |1 \times (+2) - 1 \times (+3)| = 1$$

(vii) In this reaction, ferric ions are getting reduced to ferrous ions.

$$n = |2 \times (+3) - 2 \times (+2)| = 2$$

Illustration 8. Suppose that there are three atoms A, B, C and their oxidation numbers are 6, –1, –2, respectively. Then the molecular formula of compound will be.

Solution Since, the charge on a free compound is zero. So

$$+6 = (-1 \times 4) + (-2)$$
$$+6 = -6$$
or $$+6 = (-1 \times 2) + (-2 \times 2)$$
$$= -2 + (-4) = -6$$

So molecular formula, AB_4C or AB_2C_2.

BEGINNER'S BOX-2

1. Molecular weight of $KMnO_4$ in acidic medium and neutral medium will be respecitvely –

(1) 7 × equivalent weight and 2 × equivalent weight

(2) 5 × equivalent weight and 3 × equivalent weight

(3) 4 × equivalent weight and 5 × equivalent weight

(4) 2 × equivalent weight and 4 × equivalent weight

2. In acidic medium, equivalent weight of $K_2Cr_2O_7$ (Molecular weight = M) is –

(1) M/3 (2) M/4

(3) M/6 (4) M/2

6.5 OXIDATION AND REDUCTION :

There are two concepts of oxidation and reduction.

(A) Classical/old concept :

	OXIDATION	REDUCTION
(1)	Addition of O_2	Addition of H_2
	$2Mg + O_2 \rightarrow 2MgO$	$N_2 + 3H_2 \rightarrow 2NH_3$
	$C + O_2 \rightarrow CO_2$	$H_2 + Cl_2 \rightarrow 2HCl$
(2)	Removal of H_2	Removal of O_2
	$H_2S + Cl_2 \rightarrow 2HCl + S$ (oxidation of H_2S)	$CuO + C \rightarrow Cu + CO$ (reduction of CuO)
	$4HI + O_2 \rightarrow 2I_2 + 2H_2O$ (oxidation of HI)	$H_2O + C \rightarrow CO + H_2$ (reduction of H_2O)
(3)	Addition of electronegative element	Addition of electropositive element
	$Fe + S \rightarrow FeS$ (oxidation of Fe)	$CuCl_2 + Cu \rightarrow Cu_2Cl_2$ (reduction of $CuCl_2$)
	$SnCl_2 + Cl_2 \rightarrow SnCl_4$ (oxidation of $SnCl_2$)	$HgCl_2 + Hg \rightarrow Hg_2Cl_2$ (reduction of $HgCl_2$)
(4)	Removal of electropositive element	Removal of electronegative element
	$2NaI + H_2O_2 \rightarrow 2NaOH + I_2$ (oxidation of NaI)	$2FeCl_3 + H_2 \rightarrow 2FeCl_2 + 2HCl$ (reduction of $FeCl_3$)

(B) Electronic/Modern Concept :

	OXIDATION	REDUCTION
(1)	De-electronation	Electronation
(2)	Oxidation process are those process in which one or more e^-s are lost by an atom, ion or molecule.	Reduction process are those process in which one or more e^-s are gained by an atom, ion or molecule.
(3)	Example -	
	(a) $Zn \rightarrow Zn^{+2} + 2e^-$	$Cu^{+2} + 2e^- \rightarrow Cu$
	$M \rightarrow M^{n+} + ne^-$	$M^{n+} + ne^- \rightarrow M$
	(b) $Sn^{+2} \rightarrow Sn^{+4} + (4-2)\ e^-$	$Fe^{+3} + (3-2)\ e^- \rightarrow Fe^{+2}$
	$M^{+n_1} \rightarrow M^{+n_2} + (n_2-n_1)e^-$	$M^{+x_1} + (x_1-x_2)e^- \rightarrow M^{+x_2}$
	(c) $Cl^- \rightarrow Cl + e^-$	$O + 2e^- \rightarrow O^{2-}$
	$A^{-n} \rightarrow A + ne^-$	$A + xe^- \rightarrow A^{-x}$
	(d) $MnO_4^{-2} \rightarrow MnO_4^- + (2-1)e^-$	$[Fe\ (CN)_4]^{3-} + (4-3)e^- \rightarrow [Fe\ (CN)_4]^{-4}$
	$A^{-n_1} \rightarrow A^{-n_2} + (n_1-n_2)e^-$	$A^{-n_1} + (n_2-n_1)e^- \rightarrow A^{-n_2}$

6.6 TYPES OF REDOX REACTIONS :

(A) Intermolecular redox reaction :- When oxidation and reduction takes place separately in different compounds, then the reaction is called intermolecular redox reaction.

$$SnCl_2 + 2FeCl_3 \longrightarrow SnCl_4 + 2FeCl_2$$

$$Sn^{+2} \longrightarrow Sn^{+4} \text{ (Oxidation)}$$

$$Fe^{+3} \longrightarrow Fe^{+2} \text{ (Reduction)}$$

(B) Intramolecular redox reaction :- During the chemical reaction, if oxidation and reduction takes place in single compound then the reaction is called intramolecular redox reaction.

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

$$Cl^{+5}O^{-2} \qquad Cl^{-1} \qquad O^{\circ}$$

Reduction

Oxidation

(C) Disproportionation reaction :- When reduction and oxidation takes place in the same element of the same compound then the reaction is called disproportionation reaction.

$$H_2O_2 \longrightarrow H_2O + 1/2\ O_2$$

$$O^{-1} \qquad O^{-2} \qquad O^{\circ}$$

Reduction

Oxidation

(D) Comproportionation reaction: Reverse of disproportionation reaction known as comproportionation reaction. **Ex.** $HClO + Cl^- \rightarrow Cl_2 + OH^-$

BEGINNER'S BOX-3

1. Oxidation is defined as –

(1) Gain of electrons
(2) Decrease in positive valency
(3) Loss of electrons
(4) Addition of electropositive element

2. Reduction is defined as –

(1) Increase in positive valency
(2) Gain of electrons
(3) Loss of protons
(4) Decrease in negative valency

3. In the reaction $MnO_4^- + SO_3^{-2} + H^+ \longrightarrow SO_4^{-2} + Mn^{2+} + H_2O$

(1) MnO_4^- and H^+ both are reduced
(2) MnO_4^- is reduced and H^+ is oxidised
(3) MnO_4^- is reduced and SO_3^{2-} is oxidised
(4) MnO_4^- is oxidised and SO_3^{2-} is reduced

4. The charge on cobalt in $[Co(CN)_6]^{-3}$ is –

(1) –6 (2) –3 (3) +3 (4) +6

5. Which of the following halogen always show only one oxidating state in its compounds?

(1) Cl (2) F (3) Br (4) I

6. Which of the following reactions do not involve oxidation-reduction ?

(1) $2Rb + 2H_2O \longrightarrow 2RbOH + H_2$ (2) $2CuI_2 \longrightarrow 2CuI + I_2$

(3) $NH_4Cl + NaOH \longrightarrow NaCl + NH_3 + H_2O$ (4) $3Mg + N_2 \longrightarrow Mg_3N_2$

7. The fast reaction between water and sodium is the example of –

(1) Oxidation (2) Reduction (3) Intermolecular redox (4) Intramolecular redox

8. Choose the redox reaction from the following–

(1) $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$ (2) $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$

(3) $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$ (4) $KNO_3 + H_2SO_4 \longrightarrow 2HNO_3 + K_2SO_4$

9. Which of the following is not a redox reaction ?

(1) $MnO_4^- \longrightarrow MnO_2 + O_2$ (2) $Cl_2 + H_2O \longrightarrow HCl + HClO$

(3) $2CrO_4^{2-} + 2H^+ \longrightarrow Cr_2O_7^{2-} + H_2O$ (4) $MnO_4^- + 8H^+ + 5Ag \longrightarrow Mn^{+2} + 4H_2O + 5Ag^+$

10. In the reaction $6Li + N_2 \longrightarrow 2Li_3N$

(1) Li undergoes reduction (2) Li undergoes oxidation

(3) N undergoes oxidation (4) Li is oxidant

11. $H_2O_2 + H_2O_2 \longrightarrow 2H_2O + O_2$ is an example of dispropotionation because –

(1) Oxidation number of oxygen only decreases

(2) Oxidation number of oxygen only increases

(3) Oxidation number of oxygen decreases as well as increase

(4) Oxidation number of oxygen neither decreases nor increases

---

6.7 BALANCING OF REDOX REACTION :

(A) Oxidation number change method.

(B) Ion electron method.

(A) Oxidation number change method :

This method was given by Johnson. In a balanced redox reaction, total increase in oxidation number must be equal to total decreases in oxidation number. This equivalence provides the basis for balancing redox reactions.

The general procedure involves the following steps :

(i) Select the atom in oxidising agent whose oxidation number decreases and indicate the gain of electrons.

(ii) Select the atom in reducing agent whose oxidation number increases and indicate the loss of electrons.

(iii) Now cross multiply i.e.multiply oxidising agent by the number of loss of electrons and reducing agent by number of gain of electrons.

(iv) Balance the number of atoms on both sides whose oxidation numbers change in the reaction.

(v) In order to balance oxygen atoms, add H_2O molecules to the side deficient in oxygen.

(vi) Then balance the number of H atoms by adding H^+ ions to the side deficient in hydrogen.

Illustrations

Illustration 9. Balance the following reaction by the oxidation number method –

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$

Solution Write the oxidation number of all the atoms.

$$\overset{0}{Cu} + \overset{+1+5-2}{HNO_3} \longrightarrow \overset{+2+5-2}{Cu(NO_3)_2} + \overset{+4\ -2}{NO_2} + \overset{+1\ -2}{H_2O}$$

There is change in oxidation number of Cu and N.

$$\overset{0}{Cu} \longrightarrow \overset{+2+5-2}{Cu(NO_3)_2} \quad ....(1)\ \text{(Oxidation no. is increased by 2)}$$

$$\overset{+5}{HNO_3} \longrightarrow \overset{+4}{NO_2} \quad ....(2)\ \text{(Oxidation no. is decreased by 1)}$$

To make increase and decrease equal, eq. (2) is multiplied by 2.

$$Cu + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + H_2O$$

Balancing nitrates ions, hydrogen and oxygen, the following equation is obtained.

$$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

This is the balanced equation.

Illustration 10. Balance the following reaction by the oxidation number method –

$$MnO_4^- + Fe^{+2} \longrightarrow Mn^{+2} + Fe^{+3}$$

Solution Write the oxidation number of all the atoms.

$$\overset{+7\ -2}{MnO_4^-} + Fe^{+2} \longrightarrow Mn^{+2} + Fe^{+3}$$

change in oxidation number has occured in Mn and Fe.

$$\overset{+7}{MnO_4^-} \longrightarrow Mn^{+2} \quad ....(1)\ \text{(Decrement in oxidation no. by 5)}$$

$$Fe^{+2} \longrightarrow Fe^{+3} \quad ....(2)\ \text{(Increment in oxidation no. by 1)}$$

To make increase and decrease equal, eq. (2) is multiplied by 5.

$$MnO_4^- + 5Fe^{+2} \longrightarrow Mn^{+2} + 5Fe^{+3}$$

To balance oxygen, $4H_2O$ are added to R.H.S. and to balance hydrogen, $8H^+$ are added to L.H.S.

$$MnO_4^- + 5Fe^{+2} + 8H^+ \longrightarrow Mn^{+2} + 5Fe^{+3} + 4H_2O$$

This is the balanced equation.

(B) Ion-Electron method :-

This method was given by Jette and La Mev in 1972.

The following steps are followed while balancing redox reaction (equations) by this method.

(i) Write the equation in ionic form.

(ii) Split the redox equation into two half reactions, one representing oxidation and the other representing reduction.

(iii) Balance these half reactions separately and then add by multiplying with suitable coefficients so that the electrons are cancelled. Balancing is done using following substeps.

(a) Balance all other atoms except H and O.

(b) Then balance oxygen atoms by adding H_2O molecules to the side deficient in oxygen. The number of H_2O molecules added is equal to the deficiency of oxygen atoms.

(c) Balance hydrogen atoms by adding H^+ ions equal to the deficiency in the side which is deficient in hydrogen atoms.

(d) Balance the charge by adding electrons to the side which is rich in +ve charge. i.e. deficient in electrons. Number of electrons added is equal to the deficiency.

(e) Multiply the half equations with suitable coefficients to equalize the number of electrons.

(iv) Add these half equations to get an equation which is balanced with respect to charge and atoms.

(v) If the medium of reaction is basic, OH^- ions are added to both sides of balanced equation, which is equal to number of H^+ ions in Balanced Equation.

Illustrations

Illustration 11. Balance the following reaction by ion-electron method in acidic medium :

$$Cr_2O_7^{2-} + C_2O_4^{2-} \longrightarrow Cr^{3+} + CO_2$$

Solution $Cr_2O_7^{2-} + C_2O_4^{2-} \longrightarrow Cr^{3+} + CO_2$

(a) Write both the half reaction.

$Cr_2O_7^{2-} \longrightarrow Cr^{3+}$ (Reduction half reaction)

$C_2O_4^{2-} \longrightarrow CO_2$ (Oxidation half reaction)

(b) Atoms other than H and O are balanced.

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$

$C_2O_4^{2-} \longrightarrow 2CO_2$

(c) Balance O-atoms by the addition of H_2O to another side

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$C_2O_4^{2-} \longrightarrow 2CO_2$

(d) Balance H-atoms by the addition of H^+ to another side

$Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O$

$C_2O_4^{2-} \longrightarrow 2CO_2$

(e) Now, balance the charge by the addition of electron (e^-).

$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$ ....(1)

$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$ ....(2)

(f) Multiply equations by a constant to get the same number of electrons on both side. In the above case second equation is multiplied by 3 and then added to first equation.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$

$$3C_2O_4^{2-} \longrightarrow 6CO_2 + 6e^-$$

$$Cr_2O_7^{2-} + 3C_2O_4^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6CO_2 + 7H_2O$$

Illustration 12. Balance the following reaction by ion-electron method :

$$Cr(OH)_3 + IO_3^- \xrightarrow{OH^-} I^- + CrO_4^{2-}$$

Solution $Cr(OH)_3 + IO_3^- \xrightarrow{OH^-} I^- + CrO_4^{2-}$

(a) Separate the two half reactions.

$Cr(OH)_3 \longrightarrow CrO_4^{2-}$ (Oxidation half reaction)

$IO_3^- \longrightarrow I^-$ (Reduction half reaction)

(b) Balance O-atoms by adding H_2O.

$H_2O + Cr(OH)_3 \longrightarrow CrO_4^{2-}$

$IO_3^- \longrightarrow I^- + 3H_2O$

(c) Balance H-atoms by adding H^+ to side having deficiency and add equal no. of OH^- ions to the side ($\because$ medium is known)

$$H_2O + Cr(OH)_3 \longrightarrow CrO_4^{-2} + 5H^+$$

$$5OH^- + H_2O + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 5H^+ + 5OH^-$$

or $5OH^- + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 4H_2O$

$$IO_3^- + 6H^+ \longrightarrow I^- + 3H_2O$$

$$IO_3^- + 6H^+ + 6OH^- \longrightarrow I^- + 3H_2O + 6OH^-$$

or $IO_3^- + 3H_2O \longrightarrow I^- + 6OH^-$

(d) Balance the charges by adding electrons

$$5OH^- + Cr(OH)_3 \longrightarrow CrO_4^{2-} + 4H_2O + 3e^-$$

$$IO_3^- + 3H_2O + 6e^- \longrightarrow I^- + 6OH^-$$

(e) Multiply first equation by 2 and add to second to give

$$10OH^- + 2Cr(OH)_3 \longrightarrow 2CrO_4^{2-} + 8H_2O + 6e^-$$

$$IO_3^- + 3H_2O + 6e^- \longrightarrow I^- + 6OH^-$$

6.8 LAW OF EQUIVALENCE

The law states that one equivalent of an element combine with one equivalent of the other, and in a chemical reaction equal number of equivalents or milli equivalents of reactants react to give equal number of equivalents or milli equivalents of products separately.

According :

(i) $aA + bB \rightarrow mM + nN$

m. eq of A = number of m. eq of B = number of m. eq of M = number of m. eq of N

(ii) In a compound M_xN_y

Number of m. eq of M_xN_y = m.eq of M = number of m.eq of N

GOLDEN KEY POINTS

- **FOR REDOX REACTIONS :**

  $N_1V_1 = N_2V_2$ is always true.

  But $(M_1 \times V_1) \times n_1 = (M_2 \times V_2) \times n_2$ (always true where n term represents valency factor).

Illustrations

Illustration 13 Calculate the normality of a solution containing 15.8 g of $KMnO_4$ in 50 mL acidic solution.

Solution **Normality (N)** = $\dfrac{W \times 1000}{E \times VmL}$

where W = 15.8 g, V = 50 mL $\quad E = \dfrac{\text{molar mass of } KMnO_4}{\text{Valence factor}} = 158/5 = 31.6$

So, N = 10

Illustration 14 Calculate the normality of a solution containing 50 mL of 5 M solution $K_2Cr_2O_7$ in acidic medium.

Solution Normality (N) = Molarity $\times$ Valency factor= $5 \times 6 = 30$ N

Illustration 15 Find the number of moles of $KMnO_4$ needed to oxidise one mole Cu_2S in acidic medium.

The reaction is $KMnO_4 + Cu_2S \longrightarrow Mn^{2+} + Cu^{2+} + SO_2$

Solution From law of equivalence

equivalents of Cu_2S = equivalents of $KMnO_4$

moles of $Cu_2S \times$v.f = moles of $KMnO_4 \times$v.f.

$1 \times 8 = n_2 \times 5$

$$n_2 = \frac{8}{5} = 1.6$$

Illustration 16 The number of moles of oxalate ions oxidized by one mole of MnO_4^- ion in acidic medium.

(A) $\frac{5}{2}$ (B) $\frac{2}{5}$ (C) $\frac{3}{5}$ (D) $\frac{5}{3}$

Solution Equivalents of $C_2O_4^{2-}$ = equivalents of MnO_4^-

x (mole) $\times 2 = 1 \times 5$; $x = \frac{5}{2}$

Illustration 17 What volume of 6 M HCl and 2 M HCl should be mixed to get two litre of 3 M HCl ?

Solution Let, the volume of 6 M HCl required to obtain 2 L of 3M HCl = x L

$\therefore$ Volume of 2 M HCl required = (2 − x) L

M_1V_1	+ M_2V_2	= M_3V_3
6M HCl	2M HCl	3M HCl

$6 \times (x) + 2 \times (2 - x) = 3 \times 2$

$\Rightarrow 6x + 4 - 6x = 6 \Rightarrow 4x = 2$

$\therefore$ x = 0.5 L

Hence, volume of 6 M HCl required = 0.5 L

Volume of 2M HCl required = 1.5 L

Illustration 18 In a reaction vessel, 1.184 g of NaOH is required to be added for completing the reaction. How many millilitre of 0.15 M NaOH should be added for this requirement ?

Solution Amount of NaOH present in 1000 mL of 0.15 M NaOH = $0.15 \times 40 = 6$ g

$\therefore$ 1 mL of this solution contain NaOH $= \dfrac{6}{1000} \times 10^{-3}$ g

$\therefore$ 1.184 g of NaOH will be present in $= \dfrac{1}{6 \times 10^{-3}} \times 1.184 = 197.33$ mL

Illustration 19 What weight of Na_2CO_3 of 85% purity would be required to prepare 45.6 mL of 0.235N H_2SO_4 ?

Solution Meq. of Na_2CO_3 = Meq. of H_2SO_4 = 45.6×0.235

$$\therefore \frac{W_{Na_2CO_3}}{E_{Na_2CO_3}} \times 1000 = 45.6 \times 0.235 \Rightarrow \frac{W_{Na_2CO_3}}{106/2} \times 1000 = 45.6 \times 0.235$$

$\therefore$ $W_{Na_2CO_3} = 0.5679$ g

For 85 g of pure Na_2CO_3, weight of sample = 100 g

$\therefore$ For 0.5679 g of pure Na_2CO_3, weight of sample $= \dfrac{100}{85} \times 0.5679 = 0.6681$ g

Illustration 20 The number of moles of $KMnO_4$ that will be required to react with 2 mol of ferrous oxalate is

(A) $\dfrac{6}{5}$ (B) $\dfrac{2}{5}$ (C) $\dfrac{4}{5}$ (D) 1

Solution $Mn^{7+} + 5e^- \rightarrow Mn^{2+}$] $\times 3$

$$\left.\begin{array}{l} Fe^{2+} \rightarrow Fe^{3+} + e^- \\ C_2O_4^{2-} \rightarrow 2CO_2 + 2e^- \end{array}\right] \times 5$$

3 moles of $KMnO_4$ = 5 moles of FeC_2O_4

$\therefore$ 2 mol of ferrous oxalate $\equiv \dfrac{6}{5}$ mole of $KMnO_4$

Hence, (A) is the correct answer.

Illustration 21 What volume of 6 M HNO_3 is needed to oxidize 8 g of Fe^{2+} to Fe^{3+}, HNO_3 gets converted to NO?

(A) 8 mL (B) 7.936 mL (C) 32 mL (D) 64 mL

Solution Meq. of HNO_3 = Meq. of Fe^{2+}

or $6 \times 3 \times V = \dfrac{8}{56} \times 1000$

V = 7.936 mL

valency factor = 3

$(\overset{+5}{NO_3^-} \rightarrow \overset{2+}{NO})$

Hence, (B) is the correct answer.

Illustration 22 Which of the following is / are correct?

(A) g mole weight = molecular weight in g = wt. of 6.02×10^{23} molecules

(B) mole = N_A molecule = 6.02×10^{23} molecules

(C) mole = g molecules

(D) none of the above

Solution **Ans.** (A), (B) and (C)

BEGINNER'S BOX-4

1. In the half reaction : $2ClO_3^- \longrightarrow Cl_2$

(1) 5 electrons are gained

(2) 5 electrons are liberated

(3) 10 electrons are gained

(4) 10 electrons are liberated

2. The number of electrons required to balance the following equation –

$NO_3^- + 4H^+ + e^- \longrightarrow 2H_2O + NO$ are –

(1) 5 (2) 4 (3) 3 (4) 2

3. Which of the following equations is a balanced one –

(1) $5BiO_3^- + 22H^+ + Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + MnO_4^-$

(2) $5BiO_3^- + 14H^+ + 2Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + 2MnO_4^-$

(3) $2BiO_3^- + 4H^+ + Mn^{2+} \longrightarrow 2Bi^{3+} + 2H_2O + MnO_4^-$

(4) $6BiO_3^- + 12H^+ + 3Mn^{2+} \longrightarrow 6Bi^{3+} + 6H_2O + 3MnO_4^-$

ANSWER KEY

BEGINNER'S BOX-1	**Que.**	1	2	3	4	5	6				
	Ans.	**2**	**3**	**1**	**2**	**4**	**2**				
BEGINNER'S BOX-2	**Que.**	1	2								
	Ans.	**2**	**3**								
BEGINNER'S BOX-3	**Que.**	1	2	3	4	5	6	7	8	9	10
	Ans.	**3**	**2**	**3**	**3**	**2**	**3**	**3**	**1**	**3**	**2**
	Que.	11									
	Ans.	**3**									
BEGINNER'S BOX-4	**Que.**	1	2	3							
	Ans.	**3**	**3**	**2**							

EXERCISE-I (Conceptual Questions)

OXIDATION NUMBER

1. In $[Ni(CO)_4]$, the oxidation state of Ni is :
(1) 4 (2) 0 (3) 2 (4) 8

2. The oxidation number of nitrogen in NH_2OH is :
(1) 0 (2) +1 (3) –1 (4) –2

3. Of the following elements, which one has the same oxidation state in all of its compounds ?
(1) Hydrogen (2) Fluorine
(3) Carbon (4) Oxygen

4. Oxidation number of fluorine in OF_2 is :
(1) +1 (2) +2 (3) –1 (4) –2

5. The oxidation number of C in CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$ and CCl_4 are respectively :
(1) +4, +2, 0, –2, –4 (2) +2, +4, 0, –4, –2
(3) –4, –2, 0, +2, +4 (4) –2, –4, 0, +4,. +2

6. Phosphorus has the oxidation state of +3 in :
(1) Ortho phosphoric acid (2) Phosphorus acid
(3) Meta phosphoric acid (4) Pyrophosphoric acid

7. Oxidation state of oxygen in hydrogen peroxide is
(1) –1 (2) +1 (3) 0 (4) –2

8. The oxidation number of Pt in $[Pt(C_2H_4)Cl_3]^-$ is :
(1) +1 (2) +2 (3) +3 (4) +4

9. Which one of the following statements is not correct?
(1) Oxidation state of S in $(NH_4)_2S_2O_8$ is +6
(2) Oxidation number of Os in OsO_4 is +8
(3) Oxidation state of S in H_2SO_5 is +8
(4) Oxidation number of O in KO_2 is $-\frac{1}{2}$

10. Which of the following shows highest oxidation number in combined state :
(1) Os (2) Ru
(3) Both (1) and (2) (4) None

11. Oxidation number of sodium in sodium amalgam is :
(1) +2 (2) +1 (3) –3 (4) Zero

12. Oxidation state of nitrogen is incorrectly given for:

Compound	**Oxidation State**
(1) $[Co(NH_3)_5Cl]Cl_2$	–3
(2) NH_2OH	–1
(3) $(N_2H_5)_2SO_4$	+2
(4) Mg_3N_2	–3

13. Oxidation number of C in HNC is :
(1) +2 (2) –3 (3) +3 (4) Zero

14. Oxidation number of Fe in $Fe_{0.94}$ O is :
(1) 200 (2) 200/94
(3) 94/200 (4) None

15. Oxidation number of carbon in carbon suboxide (C_3O_2) is :
(1) $\frac{+2}{3}$ (2) $\frac{+4}{3}$ (3) +4 (4) $\frac{-4}{3}$

16. Oxidation number of sulphur in $Na_2S_2O_3$ would be :-
(1) +2 (2) +4 (3) –2 (4) 0

17. Two oxidation states for chlorine are found in the compound :
(1) $CaOCl_2$ (2) KCl (3) $KClO_3$ (4) Cl_2O_7

18.

Compounds		O.N.
(A) KMn^*O_4	(1)	+4
(B) $[Ni^*(CO)_4]$	(2)	+7
(C) $[Pt^*(NH_3)Cl_2]Cl_2$	(3)	0
(D) $Na_2O_2^*$	(4)	–1

The correct code for the O.N. of asterisked atom would be :

	A	B	C	D
(1)	1	2	3	4
(2)	4	3	2	1
(3)	2	3	1	4
(4)	4	1	2	3

19. –1/3 oxidation state of nitrogen will be obtained in case of :
(1) Ammonia (NH_3) (2) Hydrazoic acid (N_3H)
(3) Nitric oxide (NO) (4) Nitrous oxide (N_2O)

20. Oxidation number of Fe in Fe_3O_4 are :
(1) +2 and +3 (2) +1 and +2
(3) +1 and +3 (4) None

21. Compound $YBa_2Cu_3O_7$ is a super conductor. The O.N. of the copper in the compound will be:[O.No. of Y=+3]

(1) +7/3 (2) zero (3) +2 (4) +1

22. The oxidation state of iodine in $H_4IO_6^-$ is :-

(1) +7 (2) –1
(3) +5 (4) +1

23. Amongst the following, identify the species with an atom in + 6 oxidation state:-

(1) MnO_4^- (2) $Cr(CN)_6^{3-}$
(3) NiF_6^{2-} (4) CrO_2Cl_2

24. The oxidation state of + 1 for phosphorous is found in:-

(1) Phosphorous acid (H_3PO_3)
(2) Orthophosphoric acid (H_3PO_4)
(3) Hypo phosphorous acid (H_3PO_2)
(4) Hypo phosphoric acid ($H_4(P_2O_6)$)

25. In which of the following compounds iron has lowest oxidation state:-

(1) $FeSO_4(NH_4)_2SO_4.6H_2O$
(2) $K_4[Fe(CN)_6]$
(3) $[Fe(CO)_5]$
(4) $Fe_{0.94}O$

26. Select the compound in which the oxidation number of oxygen is –1:-

(1) H_2O (2) O_2F_2
(3) Na_2O (4) BaO_2

27. Match List - I (compound) with list - II (Oxidation state of N) and select the correct answer using the codes given below the list:-

List - I	List-II
(A) KNO_3	(a) – 1/3
(B) HNO_2	(b) – 3
(C) NH_4Cl	(c) 0
(D) NaN_3	(d) + 3
	(e) + 5

Codes are:-

	A	B	C	D
(1)	e	d	b	a
(2)	e	b	d	a
(3)	d	e	a	c
(4)	b	c	d	e

28. In which of the following pair oxidation number of Fe is same :-

(1) $K_3[Fe(CN)_6]$, Fe_2O_3 (2) $Fe(CO)_5$, Fe_2O_3
(3) Fe_2O_3, FeO (4) $Fe_2(SO_4)_3$, $K_4[Fe(CN)_6]$

29. In the conversion of Br_2 to BrO_3^- the oxidation state of bromine changes from :-

(1) 0 to 5 (2) 1 to 5 (3) 0 to –3 (4) 2 to 5

30. The sum of oxidation states of sulphur in $H_2S_2O_8$ is :-

(1) +2 (2) +6 (3) +7 (4) +12

31. In which of the following compounds of Cr, the oxidation number of Cr is not +6 :-

(1) CrO_3 (2) CrO_2Cl_2
(3) Cr_2O_3 (4) $K_2Cr_2O_7$

32. Oxidation state of cobalt in $[Co(NH_3)_4(H_2O)Cl]SO_4$ is

(1) 0 (2) +4 (3) –2 (4) +3

33. Oxidation number of carbon in graphite is :-

(1) Zero (2) +1 (3) +4 (4) +2

34. Oxidation number of 'N' in N_3H (hydrazoic acid) is :-

(1) $-\frac{1}{3}$ (2) –3 (3) +3 (4) $+\frac{2}{3}$

35. Phosphorous has the oxidation state of +3 in :-

(1) Phosphorus acid
(2) Orthophosphoric acid
(3) Meta phosphoric acid
(4) Pyro phosphoric acid

36. The oxidation number of arsenic atom in H_3AsO_4 is :-

(1) –1 (2) –3 (3) +3 (4) +5

37. In substance $Mg(HXO_3)$, the oxidation number of X is :-

(1) 0 (2) +2 (3) +3 (4) +4

38. Oxidation number of P in KH_2PO_3 is :–

(1) – 1 (2) – 3 (3) + 5 (4) + 3

39. The oxidation number of iron in potassium ferricyanide $K_3[Fe (CN)_6]$ is :–

(1) Two (2) Six
(3) Three (4) Four

40. The oxidation number of phosphorus in PH_4^+, PO_2^{3-}, PO_4^{3-} and PO_3^{3-} are respectively :–
(1) –3, +1, +3, +5 (2) –3, +3, +5, +1
(3) +3, –3, +5, +1 (4) –3, +1, +5, +3

41. Which of the following compounds are arranged in increasing oxidation number of S :–
(1) H_2SO_3, H_2S, H_2SO_4, $H_2S_2O_3$
(2) $H_2S_2O_3$, H_2SO_3, H_2S, H_2SO_4
(3) H_2S, H_2SO_3, H_2SO_4, $H_2S_2O_3$
(4) H_2S, $H_2S_2O_3$, H_2SO_3, H_2SO_4

42. Iodine shows the highest oxidation state in the compound :–
(1) KI (2) KI_3 (3) IF_5 (4) KIO_4

43. The sum of the oxidation states of all the carbon atoms present in the compound C_6H_5CHO is :
(1) –4 (2) 3 (3) + 5 (4) – 4/7

44. Oxidation number of sodium in sodium amalgam is
(1) +1 (2) 0
(3) –1 (4) +2

APPLICATIONS OF REDOX REACTIONS

45. A reducing agent is a substance which can :
(1) Accept electrons (2) Donate electrons
(3) Accept protons (4) Donate protons

46. The reaction $H_2S + H_2O_2 \rightarrow S + 2H_2O$ manifests :
(1) Oxidising action of H_2O_2
(2) Reducing nature of H_2O_2
(3) Acidic nature of H_2O_2
(4) Alkaline nature of H_2O_2

47. If an element is in its lowest oxidation state, under proper conditions it can act as :
(1) Reducing agent
(2) An oxidising agent
(3) Oxidising as well as reducing agent
(4) Neither oxidising nor reducing agent

48. In a reaction of H_2O (steam) + C (glowing) $\rightarrow CO + H_2$
(1) H_2O is the reducing agent
(2) H_2O is the oxidising agent
(3) carbon is the oxidising agent
(4) oxidation-reduction does not occur

49. The compound that can work both as an oxidising as well as reducing agent is :
(1) $KMnO_4$ (2) H_2O_2
(3) $Fe_2(SO_4)_3$ (4) $K_2Cr_2O_7$

50. Reaction (A) $S^{-2} + 4\,H_2O_2 \rightarrow SO_4^{2-} + 4\,H_2O$
(B) $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$
The true statement regarding the above reactions is :
(1) H_2O_2 acts as reductant in both the reactions.
(2) H_2O_2 acts as oxidant in reaction (A) and reductant in reaction (B).
(3) H_2O_2 acts as an oxidant in both the reactions.
(4) H_2O_2 acts as reductant in reaction (A) and oxidant in reaction(B)

51. HNO_2 acts as an oxidant with which one of the following reagent:-
(1) $KMnO_4$ (2) H_2S (3) $K_2Cr_2O_7$ (4) Br_2

52. In which of the following reaction H_2O_2 acts as reducing agent :-
(1) $2FeCl_2 + 2HCl + H_2O_2 \rightarrow 2FeCl_3 + 2H_2O$
(2) $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$
(3) $2HI + H_2O_2 \rightarrow 2H_2O + I_2$
(4) $H_2SO_3 + H_2O_2 \rightarrow H_2SO_4 + H_2O$

53. A sulphur containing species that can not be a reducing agent is :-
(1) SO_2 (2) SO_3^{-2}
(3) H_2SO_4 (4) $S_2O_3^{2-}$

54. When H_2 reacts with Na, it acts as :-
(1) Oxidising agent (2) Reducing agent
(3) Both (4) Cannot be predicted

55. Which one is the oxidising agent in the reaction given below
$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{-2} + H_2O$
(1) H^+ (2) $Cr_2O_7^{-2}$
(3) Cr^{++} (4) H_2O

56. In the course of a chemical reaction an oxidant –
(1) Loses electron
(2) Gains electron
(3) Both loses and gain electrons
(4) Electron change does not occur

57. In the reaction:-
$C + 4HNO_3 \rightarrow CO_2 + 2H_2O + 4NO_2$
HNO_3 acts as :–
(1) An oxidising agent (2) An acid
(3) A reducing agent (4) A base

58. A compound contains atoms A, B and C. The oxidation number of A is +2, of B is +5 and of C is –2. The possible formula of the compound is :
(1) ABC_2 (2) $B_2(AC_3)_2$
(3) $A_3(BC_4)_2$ (4) $A_3(B_4C)_2$

59. Equivalent weight of N_2 in the change $N_2 \rightarrow NH_3$ is
(1) $\frac{28}{6}$ (2) 28 (3) $\frac{28}{2}$ (4) $\frac{28}{3}$

60. Equivalent weight of NH_3 in the change $N_2 \rightarrow NH_3$ is :
(1) $\frac{17}{6}$ (2) 17 (3) $\frac{17}{2}$ (4) $\frac{17}{3}$

61. In the reaction, $2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$, the eq. wt. of $Na_2S_2O_3$ is equal to its :
(1) Mol. wt. (2) Mol. wt./2
(3) 2 x Mol. wt. (4) Mol. wt./6

62. In the reaction, $VO + Fe_2O_3 \rightarrow FeO + V_2O_5$, the eq. wt. of V_2O_5 is equal to its :
(1) Mol. wt. (2) Mol. wt./8
(3) Mol .wt./6 (4) Mol. wt./2

63. The eq. wt. of iodine in, $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ is :
(1) Its Mol. wt. (2) Mol. wt./2
(3) Mol. wt./4 (4) None of these

64. Molecular weight of $KBrO_3$ is M. What is its equivalent weight, if the reaction is :
$BrO_3^- \rightarrow Br^-$ (acidic medium)
(1) M (2) M/4
(3) M/6 (4) 6M

65. In the reaction : $A^{-n_2} + xe^- \rightarrow A^{-n_1}$, here x will be
(1) $n_1 + n_2$ (2) $n_2 - n_1$
(3) $n_1 - n_2$ (4) $n_1 \cdot n_2$

66. What would be the equivalent weight of the reductant in the reaction :
$[Fe(CN)_6]^{-3} + H_2O_2 + 2OH^- \rightarrow 2[Fe(CN)_6]^{4-} + 2H_2O + O_2$
[Given : Fe = 56, C = 12, N = 14, O = 16, H = 1]
(1) 17 (2) 212
(3) 34 (4) 32

67. The equivalent weight of $Na_2S_2O_3$ as reductant in the reaction,
$Na_2S_2O_3+H_2O+Cl_2 \rightarrow Na_2SO_4+2HCl+S$ is :
(1) (Mol. wt.)/1 (2) (Mol. wt.)/2
(3) (Mol. wt.)/6 (4) (Mol. wt.)/8

68. Equivalent weight of FeC_2O_4 in the change : $FeC_2O_4 \rightarrow Fe^{3+} + CO_2$ is :
(1) M/3 (2) M/6
(3) M/2 (4) M/1

69. What will be n-factor for $Ba(MnO_4)_2$ in acidic medium? (Where it behaves as oxidant)
(1) 5 (2) 10 (3) 6 (4) 3

70. The number of mole of oxalate ions oxidised by one mole of MnO_4^- is :
(1) 1/5 (2) 2/5
(3) 5/2 (4) 5

71. Oxidising product of substance Na_3AsO_3 would be
(1) $As_2O_3^{3-}$ (2) AsO_3^{-3}
(3) AsO_2^{-4} (4) AsO_4^{-3}

72. In a reaction 4 mole of electrons are transferred to one mole of HNO_3 when it acts as an oxidant. The possible reduction product is :
(1) (1/2) mole N_2 (2) (1/2) mole N_2O
(3) 1 mole of NO_2 (4) 1 mole NH_3

73. The equivalent weight of $MnSO_4$ is half of its molecular weight when it is converted to :-
(1) Mn_2O_3 (2) MnO_2
(3) MnO_4^- (4) MnO_4^{-2}

74. In the following change, $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
If the atomic weight of iron is 56, then its equivalent weight will be :-
(1) 42 (2) 21 (3) 63 (4) 84

75. $Cr_2O_7^{-2} + I^- + H^+ \rightarrow Cr^{+3} + I_2 + H_2O$
The equivalent weight of the reductant in the above equation is :– (At. wt. of Cr=52, I=127)
(1) 26 (2) 127 (3) 63.5 (4) 10.4

76. How many moles of $KMnO_4$ are reduced by 1 mole of ferrous oxalate in acidic medium:-

(1) $\frac{1}{5}$ (2) $\frac{5}{3}$ (3) $\frac{1}{3}$ (4) $\frac{3}{5}$

77. The number of moles of $KMnO_4$ reduced by one mole of KI in alkaline medium is :-

(1) One (2) Two

(3) Five (4) One fifth

REDOX REACTIONS

78. Which one of the following is a redox reaction ?

(1) $H_2 + Br_2 \rightarrow 2HBr$

(2) $2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$

(3) $HCl + AgNO_3 \rightarrow AgCl + HNO_3$

(4) $NaOH + HCl \rightarrow NaCl + H_2O$

79. Which of the following is not a redox change ?

(1) $2H_2S + SO_2 \rightarrow 2H_2O + 3S$

(2) $2BaO + O_2 \rightarrow 2BaO_2$

(3) $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

(4) $2KClO_3 \rightarrow 2KCl + 3O_2$

80. In the reaction $4Fe + 3O_2 \rightarrow 4Fe^{3+} + 6O^{2-}$ which of the following statements is incorrect ?

(1) It is a redox reaction

(2) Metallic iron is a reducing agent

(3) Fe^{3+} is an oxidising agent

(4) Metallic iron is reduced to Fe^{3+}

81. In the reaction, $Cl_2 + OH^- \rightarrow Cl^- + ClO_4^- + H_2O$, chlorine is :

(1) Oxidised

(2) Reduced

(3) Oxidised as well as reduced

(4) Neither oxidised nor reduced

82. Which is a redox reaction :

(1) $2CuI_2 \rightarrow CuI + I_2$

(2) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

(3) $NH_4Cl + NaOH \rightarrow NH_3 + NaCl + H_2O$

(4) $Cr_2(SO_4)_3 + 6KOH \rightarrow 2Cr(OH)_3 + 3K_2SO_4$

83. Which of the following example does not represent disproportionation -

(1) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

(2) $2H_2O_2 \rightarrow 2H_2O + O_2$

(3) $4KClO_3 \rightarrow 3KClO_4 + KCl$

(4) $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

84. The decomposition of $KClO_3$ to KCl and O_2 on heating is an example of :

(1) Intermolecular redox change

(2) Intramolecular redox change

(3) Disproportionation or auto redox change

(4) Comproportionation

85. Which of the following change represents a disproportionation reaction (s) :

(1) $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$

(2) $Cu_2O + 2H^+ \rightarrow Cu + Cu^{2+} + H_2O$

(3) $2HCuCl_2 \xrightarrow[\text{Water}]{\text{dilution with}} Cu + Cu^{2+} + 4Cl^- + 2H^+$

(4) All of the above

86. One mole of iron [55.8 gm], when oxidised to +2 oxidation state gives up :

(1) $1N_A$ electron (2) $2N_A$ electron

(3) $3N_A$ electron (4) 0.5 mole of electron

87. How many electrons should X_2H_4 liberate so that in the new compound X shows oxidation number of -½ (E.N. X > H)

(1) 10 (2) 4 (3) 3 (4) 2

88. Which one of the following is not a redox reaction :-

(1) $CaCO_3 \rightarrow CaO + CO_2$

(2) $2H_2 + O_2 \rightarrow 2H_2O$

(3) $Na + H_2O \rightarrow NaOH + \frac{1}{2}H_2$

(4) $MnCl_3 \rightarrow MnCl_2 + \frac{1}{2}Cl_2$

89. In the reaction -

$MnO_4^- + SO_3^{2-} + H^+ \rightarrow SO_4^{-2} + Mn^{+2} + H_2O$

(1) MnO_4^- and H^+ both are reduced

(2) MnO_4^- is reduced and H^+ is oxidised

(3) MnO_4^- is reduced and SO_3^{2-} is oxidised

(4) MnO_4^- is oxidised and SO_3^{2-} is reduced

90. $I_2 + KI \rightarrow KI_3$

In the above reaction:-

(1) Only oxidation taken place

(2) Only reduction takes place

(3) Both the above

(4) Neither oxidation nor reduction

91. Which of the following reaction represents the oxidising behaviour of H_2SO_4 :-

(1) $2PCl_5 + H_2SO_4 \rightarrow 2POCl_3 + 2HCl + SO_2Cl_2$
(2) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
(3) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
(4) $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$

92. Select the example of disproportionation reaction

(1) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$
(2) $NH_4NO_3 \rightarrow N_2O + 2H_2O$
(3) $4H_3PO_3 \rightarrow PH_3 + 3H_3PO_4$
(4) $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2Cl$

93. Which of the following reaction involves oxidation & reduction :-

(1) $NaBr + HCl \rightarrow NaCl + HBr$
(2) $HBr + AgNO_3 \rightarrow AgBr + HNO_3$
(3) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
(4) $H_2 + Br_2 \rightarrow 2HBr$

94. The reaction

$2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$ is an example of

(1) Redox (2) Reduction only
(3) Neutralization (4) Disproportionation

95. Which of the following reaction involves neither oxidation nor reduction :–

(1) $CrO_4^{2-} \rightarrow Cr_2O_7^{2-}$ (2) $Cr \rightarrow CrCl_3$
(3) $Na \rightarrow Na^+$ (4) $2S_2O_3^{2-} \rightarrow S_4O_6^{2-}$

96. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Zn undergoes –

(1) Reduction
(2) Oxidation
(3) Both oxidation and reduction
(4) Neither oxidation nor reduction

BALANCING OF REDOX REACTIONS

97. Balance the following given half reaction for the unbalanced whole reaction :

$CrO_4^{2-} \rightarrow CrO_2^- + OH^-$ is :

(1) $CrO_4^{-2} + 2H_2O + 3e^- \rightarrow CrO_2^- + 4OH^-$
(2) $2CrO_4^{-2} + 8H_2O \rightarrow CrO_2^- + 4H_2O + 8OH^-$
(3) $CrO_4^{-2} + H_2O \rightarrow CrO_2^- + H_2O + OH^-$
(4) $3CrO_4^{-2} + 4H_2O + 6e^- \rightarrow 2CrO_2^{-1} + 8OH^-$

98. Choose the set of coefficients that correctly balances the following equation :

$x\, Cr_2O_7^{2-} + yH^+ + z\, e^- \rightarrow a\, Cr^{+3} + bH_2O$

	x	**y**	**z**	**a**	**b**
(1)	2	14	6	2	7
(2)	1	14	6	2	7
(3)	2	7	6	2	7
(4)	2	7	6	1	7

99. In the reaction: $MnO_4^- + xH^+ + ne^- \rightarrow Mn^{2+} + yH_2O$

What is the value of n :

(1) 5 (2) 8
(3) 6 (4) 3

100. The number of electrons required to balance the following equation –

$NO_3^- + 4H^+ + e^- \longrightarrow 2H_2O + NO$ is

(1) 5 (2) 4
(3) 3 (4) 2

101. The molar mass of $CuSO_4.5H_2O$ is 249. Its equivalent mass in the reaction (a) and (b) would be

(a) Reaction $CuSO_4 + KI \rightarrow$ product
(b) Electrolysis of $CuSO_4$ solution.

(1) (a) 249 (b) 249 (2) (a) 124.5 (b) 124.5
(3) (a) 249 (b) 124.5 (4) (a) 124.5 (b) 249

102. $2KMnO_4 + 5H_2S + 6H^+ \rightarrow 2Mn^{2+} + 2K^+ + 5S + 8H_2O$.

In the above reaction, how many electrons would be involved in the oxidation of 1 mole of reductant?

(1) Two (2) Five
(3) Ten (4) One

103. The value of n in : $MnO_4^- + 8H^+ + ne^- \rightarrow Mn^{2+} + 4H_2O$ is

(1) 5 (2) 4
(3) 3 (4) 2

104. What is the value of n in the following equation :

$Cr(OH)_4^- + OH^- \rightarrow CrO_4^{2-} + H_2O + ne^-$?

(1) 3 (2) 6
(3) 5 (4) 2

105. For the redox reaction

$Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$ in basic medium, coefficients of Zn, NO_3^- and OH^- in the balanced equation respectively are :

(1) 4, 1, 7 (2) 7, 4, 1
(3) 4, 1, 10 (4) 1, 4, 10

106. In the balanced equation-

$[Zn + H^+ + NO_3^- \rightarrow NH_4^+ + Zn^{+2} + H_2O]$ coefficient of NH_4^+ is:-

(1) 4 (2) 3

(3) 2 (4) 1

107. In the balanced equation

$MnO_4^- + H^+ + C_2O_4^{2-} \rightarrow Mn^{2+} + CO_2 + H_2O$, the moles of CO_2 formed are :-

(1) 2 (2) 4

(3) 5 (4) 10

108. In the following reaction the value of 'X' is

$H_2O + SO_3^{2-} \rightarrow SO_4^{2-} + 2H^+ + X$

(1) $4e^-$ (2) $3e^-$

(3) $2e^-$ (4) $1e^-$

109. The number of electrons required to balance the following equation are:

$NO_3^- + 4H^+ \rightarrow 2H_2O + NO$

(1) 2 on right side (2) 3 on left side

(3) 3 on right side (4) 5 on left side

EXERCISE-I (Conceptual Questions) ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	**2**	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**3**	**3**	**4**	**3**	**1**	**2**	**2**
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	**1**	**1**	**3**	**2**	**1**	**1**	**1**	**4**	**3**	**3**	**4**	**1**	**1**	**1**	**4**
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	**3**	**4**	**1**	**1**	**1**	**4**	**3**	**4**	**3**	**4**	**4**	**4**	**1**	**2**	**2**
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**1**	**4**	**2**	**1**	**3**	**1**	**4**
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Ans.	**1**	**3**	**2**	**3**	**3**	**1**	**4**	**1**	**2**	**3**	**4**	**2**	**2**	**2**	**2**
Que.	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Ans.	**4**	**2**	**1**	**3**	**4**	**3**	**1**	**1**	**2**	**4**	**2**	**3**	**1**	**3**	**3**
Que.	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
Ans.	**4**	**3**	**4**	**1**	**1**	**2**	**1**	**2**	**1**	**3**	**3**	**1**	**1**	**1**	**3**
Que.	106	107	108	109											
Ans.	**4**	**4**	**3**	**2**											

Directions for Assertion & Reason questions

These questions consist of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(C) If Assertion is True but the Reason is False.

(D) If both Assertion & Reason are false.

1. **Assertion :–** O.N. of carbon in H–C≡N is +4.
Reason :– Carbon always shows an O.N. of +4.
(1) A (2) B (3) C (4) D

2. **Assertion :–** In NH_4NO_3, the oxidation number of the two N-atoms is not equal.
Reason :– One N atom is present in the ammonium ion while the other is present in the nitrate ion.
(1) A (2) B (3) C (4) D

3. **Assertion :–** Oxidation state of Hydrogen is +1 in H_2O while –1 in CaH_2.
Reason :– CaH_2 is a metal hydride and for metal hydrides, hydrogen is assigned the oxidation number of –1.
(1) A (2) B (3) C (4) D

4. **Assertion :–** Oxidation number of carbon in CH_2O is zero.
Reason :– CH_2O (formaldehyde) is a covalent compound.
(1) A (2) B (3) C (4) D

5. **Assertion :–** Oxidation number of Ni in $[Ni(CO)_4]$ is zero.
Reason :– Nickel is bonded to neutral ligand, carbonyl.
(1) A (2) B (3) C (4) D

6. **Assertion :–** In $HClO_4$, Chlorine has the oxidation number of +4.
Reason :– $HClO_4$ (perchloric) acid has two peroxide linkages.
(1) A (2) B (3) C (4) D

7. **Assertion :–** Oxidation number of S in HSO_3^- is +4.
Reason :– Sulphur is in different oxidation state in different compounds.
(1) A (2) B (3) C (4) D

8. **Assertion :–** Oxidation number of Carbon in all it's compounds is +4.
Reason :– An element has a fixed oxidation state.
(1) A (2) B (3) C (4) D

9. **Assertion :–** Oxidation number of Cr in CrO_5 is +6.
Reason :– In CrO_5, four oxygen atoms are involved in peroxide linkage.
(1) A (2) B (3) C (4) D

10. **Assertion :–** Oxidation number of Cr in $[Cr(CO)_6]$ is zero.
Reason :– Cr is a metal.
(1) A (2) B (3) C (4) D

11. **Assertion :-** The oxidation no. of sulphur in $Na_2S_4O_6$ is 2.5
Reason :- Two S-atoms are not directly linked with O-atoms.
(1) A (2) B (3) C (4) D

12. **Assertion :–** In the reaction, $\frac{1}{2}O_2 + F_2 \rightarrow OF_2$ Fluorine is oxidant.
Reason :– Fluorine cannot show positive oxidation state.
(1) A (2) B (3) C (4) D

13. **Assertion :–** $H_2S + Cl_2 \longrightarrow 2HCl + S$
In the above reaction, Cl has been oxidised to Cl^- while S^{-2} has been reduced to S
Reason :– In a reaction the element whose oxidation number decreases is reduced and the element whose oxidation number increases is oxidised.
(1) A (2) B (3) C (4) D

14. **Assertion :–** Nitrous acid (HNO_2) may act as an oxidising agent as well as a reducing agent.
Reason :– The oxidation number of Nitrogen remains same in all the compounds.
(1) A (2) B (3) C (4) D

15. **Assertion :–** A reducing agent is a substance which accepts electron.
Reason :– A substance which helps in oxidation is known as reducing agent.
(1) A (2) B (3) C (4) D

16. **Assertion :–** In a redox reaction, the oxidation number of the oxidant decreases while that of reductant increases.
Reason :– Oxidant gains electron(s) while reductant loses electron(s).
(1) A (2) B (3) C (4) D

17. **Assertion :–** H_2SO_4 can not act as reducing agent.
Reason :– Sulphur can not increase its oxidation number beyond +6.
(1) A (2) B (3) C (4) D

18. **Assertion :–** When Cl_2 react with conc. NaOH form NaCl & $NaClO_3$
Reason :– Cl_2 is a oxidizing agent.
(1) A (2) B (3) C (4) D

19. **Assertion :–**
$Zn(s) + Cu^{+2}(aq) \rightarrow Zn^{+2}(aq) + Cu(s)$
can be split into following half reactions
$Zn(s) \rightarrow Zn^{+2} + 2e^-$
(Oxidation half reaction)
$Cu^{+2}(aq) + 2e^- \rightarrow Cu$
(Reduction half reaction)
Reason :– Every redox reaction can be split into two reactions, one representing loss of electrons and the other representing gain of electrons.
(1) A (2) B (3) C (4) D

20. **Assertion :–** MnO_4^- is always reduced to Mn^{+2}.
Reason :– Decrease in oxidation number or gaining of electron means oxidation.
(1) A (2) B (3) C (4) D

21. **Assertion :–** $KClO_3 \longrightarrow KClO_4 + KCl$
This is a disporportionation type reaction.
Reason :– The reaction in which one substance oxidise or reduce is known as disproportionation reaction.
(1) A (2) B (3) C (4) D

22. **Assertion :–** Equivalent weight of $KMnO_4$ in acidic medium is M/5 (M=molecular weight) while in alkaline medium, it is equal to M/3.
Reason :– In acidic medium, 1 mol of MnO_4^- gains 5 mole electrons while in alkaline medium it gains 3 mole electrons.
(1) A (2) B (3) C (4) D

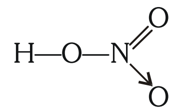
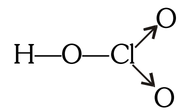
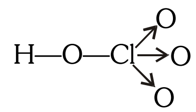
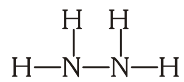
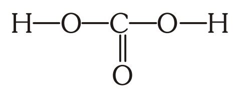
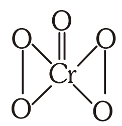
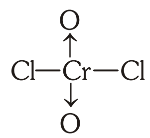
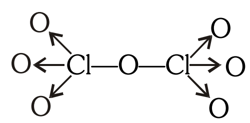
23. **Assertion :–** Bromide ion is serving as a reducing agent in the reaction.
$2MnO^-_4(aq.) + Br^-(aq.) + H_2O$
$\longrightarrow 2MnO_2(aq.) + BrO^-_3(aq.) + 2OH^-(aq.)$
Reason :– Oxidation number of Br increases from –1 to +5.
(1) A (2) B (3) C (4) D

24. **Assertion :–** Equivalent weight of NH_3 in the reaction $N_2 \rightarrow NH_3$ is 17/3 while that of N_2 is 28/6.
Reason :– Equivalent weight
$$= \frac{\text{Molecular weight}}{\text{number of } e^- \text{ lost or gained/mole}}$$
(1) A (2) B (3) C (4) D

25. **Assertion :–** In acidic medium, equivalent weight of $K_2Cr_2O_7$ is equal to 294/6.
Reason :– In acidic medium, $Cr_2O_7^{-2}$ is reduced in Cr^{+3}.
(1) A (2) B (3) C (4) D

EXERCISE-II (Assertion & Reason) ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	**4**	**1**	**1**	**2**	**1**	**4**	**2**	**4**	**1**	**2**	**1**	**2**	**4**	**3**	**4**
Que.	16	17	18	19	20	21	22	23	24	25					
Ans.	**1**	**1**	**2**	**1**	**4**	**3**	**1**	**1**	**1**	**1**					

LINE STRUCTURE OF SOME COMPOUNDS				Oxidati on state
1.	Hydrogen peroxide	H_2O_2	H — O — O — H	O = ………
2.	Nitrous acid	HNO_2	H—O—N=O	N = ………
3.	Nitric acid	HNO_3		N = ………
4.	Hypo chlorous acid	HClO	H—O—Cl	Cl = ……..
5.	Chlorous acid	$HClO_2$	H —O—Cl →O	Cl = ……..
6.	Chloric acid	$HClO_3$		Cl = ……..
7.	Perchloric acid	$HClO_4$		Cl = ……..
8.	Hydrazine	N_2H_4		N = ……..
9.	Carbonic acid	H_2CO_3		C= ……..
10.	Chromium pentoxide	CrO_5		Cr = ……..
11.	Nitrosyl chloride/ Tilden's reagent	NOCl	Cl—N=O	N = ……..
12.	Chromyl chloride	CrO_2Cl_2		Cr = ……..
13.	Perchloric anhydride	Cl_2O_7		Cl = ……..
14.	Calcium oxy-chloride/ Bleaching powder	$CaOCl_2$	Ca(O*Cl)**Cl	*Cl = …….. **Cl = ……..

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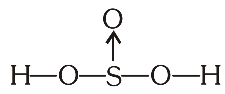
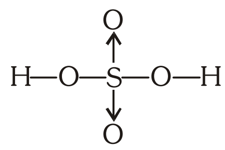
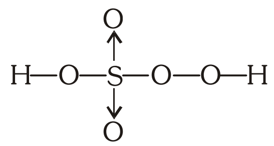
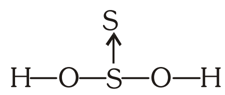
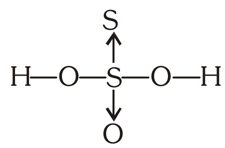
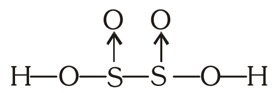
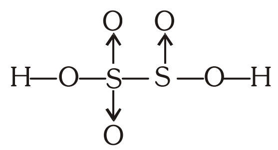
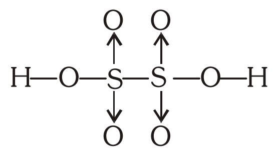
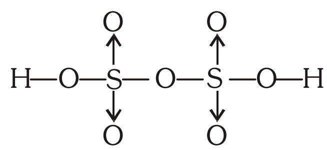
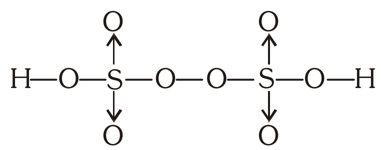
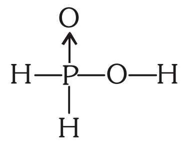
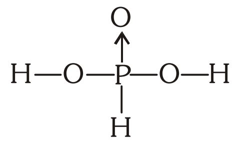
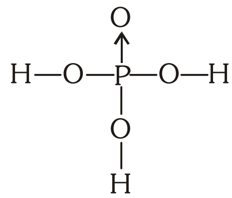
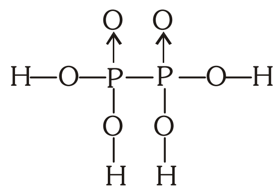
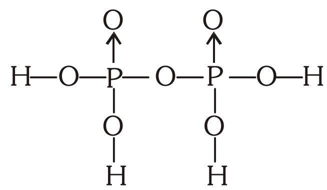
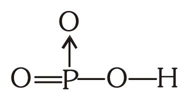
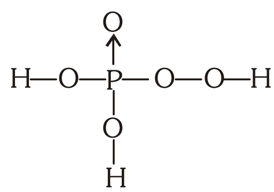
OXY ACIDS OF SULPHUR				O.S. of central Sulphur atom
1.	Sulphoxilic acid	H_2SO_2	H—O—S—O—H	
2.	Sulphurous acid	H_2SO_3		
3.	Sulphuric acid	H_2SO_4		
4.	Peroxymonosulphuric acid (Caro's acid)	H_2SO_5		
5.	Thiosulphurous acid	$H_2S_2O_2$		
6.	Thiosulphuric acid	$H_2S_2O_3$		
7.	Dithionous acid	$H_2S_2O_4$		
8.	Pyrosulphurous acid	$H_2S_2O_5$		
9.	Dithionic acid	$H_2S_2O_6$		
10.	Pyrosulphuric acid/ Fuming sulphuric acid/ Oleum	$H_2S_2O_7$		
11.	Peroxydisulphuric acid (Marshal's acid)	$H_2S_2O_8$		

OXY ACIDS OF PHOSPHOROUS				O.S. of central P atom
1.	Hypophophorous acid	H_3PO_2		
2.	Orthophosphorous acid/ Phophorous acid	H_3PO_3		
3.	Orthophosphoric acid/ Phophoric acid	H_3PO_4		
4.	Hypophosphoric acid	$H_4P_2O_6$		
5.	Pyrophosphoric acid	$H_4P_2O_7$		
6.	Metaphosphoric acid	HPO_3		
7.	Peroxymonophosphoric acid	H_3PO_5		
8.	Peroxydiphosphoric acid	$H_4P_2O_8$